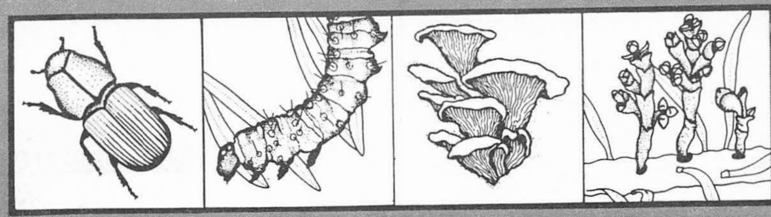
Forest Pest Management



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GROWTH IMPACT, SPREAD, AND INTENSIFICATION OF DWARF MISTLETOE IN DOUGLAS-FIR AND LODGEPOLE PINE IN MONTANA

by

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ABSTRACT

A permanent study was established in 1970 and 1971 to measure the impact, spread, and intensification of dwarf mistletoe on precommercially thinned Douglas-fir and lodgepole pine in Montana. Mean diameter growth on all plots was reduced 21 percent in Douglas-fir, but the reduction is only significant at the 0.15 level. No diameter growth reduction occurred in the lodgepole pine. Height growth was not affected in either species. Infected trees, as a percent of the total number of trees in the study, increased from 3.4 percent in 1970 to 9.2 percent in 1983 in Douglas-fir, and from 1.8 percent in 1971 to 7.4 percent in 1984 in lodgepole pine. Dwarf mistletoe rating, a measure of infection intensity, increased in some trees, decreased in some, and did not change in others.

There was no effect of thinning at this young age and low dwarf mistletoe intensity. Dwarf mistletoe intensity and impact may increase as the stands mature.

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INTRODUCTION

Dwarf mistletoes (Arceuthobium spp.) are parasitic seed plants dependent upon conifer hosts. The dwarf mistletoes and western conifers have probably evolved together since the Miocene period, or about 25 million years (Hawksworth 1978a). Dwarf mistletoes may affect their hosts in several ways:

1. They cause a reduction of height and diameter growth, with a corresponding reduction in volume growth.

2. They can kill trees directly.

3. Heavily infected trees produce fewer seeds and seeds of lower viability (Korstian and Long 1922, Munns 1919).

4. Wood in bole infections is altered. Affected wood has shorter and distorted tracheids and a greater proportion of ray tissues (Piirto and others 1974, Hunt 1971).

5. Infection weakens trees and makes them more susceptible to insects, especially bark beetles.

6. They may cause ecological effects by altering species composition through tree mortality or by increasing fire hazard (Hawksworth 1978a, Wicker 1978).

These effects create problems in some areas because of the demands we place on the forests for goods and services, but we can alleviate them to a degree through silvicultural practices.

We can decrease losses by reducing the dwarf mistletoes below the economic threshold. The study we report on here was designed to help us determine what that threshold is.

THE STUDY

Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) (DF) plots were established on the Lolo National Forest in 1970 and lodgepole pine (Pinus contorta Dougl.) (LP) plots on the Gallatin National Forest in 1971. Plots were marked for permanent location with steel fence posts at each corner, and plots were remeasured 3 years after establishment to determine amount of latent infection (DF 1973, LP 1974) and at 5-year intervals thereafter (DF 1978, 1983; LP 1979, 1984). In addition to collecting the usual mensurational data (diameter, height, crown ratio), each tree was rated for dwarf mistletoe infection using the 6-Class dwarf mistletoe rating (DMR) system (Hawksworth 1977).

Objectives of the study were to determine effects of precommercial thinning for dwarf mistletoe control on growth impact, associated mortality, and spread and intensification of dwarf mistletoe.

Four plots (DF 1.73 acres, LP 2.77 acres) with a one-half chain buffer strip were established for each replicate. Three square subplots (DF 0.25 acre, LP 0.5 acre) with a one-half chain buffer strip were superimposed upon each plot.

All subplots were to have been 0.5 acre, but because of a shortage of suitable stands, the DF subplots were reduced to 0.25 acre.

Treatment variables were precommercial thinning and dwarf mistletoe removal. Thinning treatments were applied at the plot level; subplots received different levels of dwarf mistletoe removal. The subplots were the basic treatment unit and received the combined silvicultural and dwarf mistletoe treatments.

Four silvicultural treatments were applied to plots and buffer strips:

1. Check (no thinning).

2. Crop trees (681 trees/acre) spaced 8 X 8 feet, all others removed .

3. Crop trees (222 trees/acre) spaced 14 X 14 feet, all others removed .

4. Crop trees (109 trees/acre) spaced 20 X 20 feet, all others removed .

Three dwarf mistletoe treatments were applied to subplots and buffer strips:

1. Check (no dwarf mistletoe removal).

2. Partial high: Only dominants and codominants which fit potential crop tree criteria and were free of or lightly infected with dwarf mistletoe were left. Trees were pruned to light infection (DMR 1) if necessary to achieve a stocking level.

3. Partial low: Only dominants and codominants which fit potential crop tree criteria and were free of, lightly, or moderately infected (up to DMR 3) with dwarf mistletoe were left.

There were two Douglas-fir replicates, or 24 one-fourth acre sub-plots,[2] and three lodgepole pine replicates, or 36 one-half acre subplots.

Additional details of the study are covered in an unpublished study plan dated July 1970 on file in the Northern Region office.

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[2]There are actually 25. One of the check/check plots was thinned by mistake to 14 x 14 feet, and a substitute was established in 1971.

DATA ANALYSIS

We compared actual growth with predicted growth using a diameter growth model similar to the one used in the Prognosis Model for stand development (Wykoff and others 1982), which uses the individual tree as the basic unit of growth projection. By using tree data from the study and keeping the site variables constant, we found the variables that had an effect on growth were:

1. Position of tree in the basal area (BA) distribution.

2. BA of stand.

3. Size of tree.

4. Grouped DMR's equal to or greater than 3.

5. Crown ratio.

We did an analysis of variance by multiple regression on the resulting growth calculations.

RESULTS

Growth Impact

Diameter--The analysis of variance for the Douglas-fir plots is shown in table 1. Variables are defined as:

LNDDS = Log (change in diameter squared)

LNDBH = Log (diameter breast height)

BBAL = Basal area of larger trees at beginning of 10-year period

MISTDUM1 = Grouped DMR's less than 3

CR = Crown ratio

MISTDUM2 = Grouped DMR's equal to or greater than 3

$$\text{BALLND} = \frac{\text{Basal area of larger trees}}{\text{Log (1 + diameter breast height)}}$$

The effect of DMR's less than 3 is not significant, and DMR's equal to or greater than 3 have an effect on diameter growth that is significant at the 0.15 level. The multiplier for the dwarf mistletoe effect on Douglas-fir is 0.79, or a reduction in diameter growth of about 21 percent.

The analysis of variance for the lodgepole pine plots is shown in table 2. MISTDUM1 in this case is all DMR's combined. They were combined because only a few trees had DMR's equal to or greater than 3. The effect of dwarf mistletoe is not significant.

Table 1.--Analysis of the effect of dwarf mistletoe on Douglas-fir growth predictions.

Multiple R	.62245	Analysis of variance			
R Square	.38745		DF	Sum of squares	Mean square
Adjusted R Square	.38299	Regression	6	184.01627	30.66938
Standard Error	.59419	Residual	824	29C.92716	.35307

F = 86.86542 SIGNIF F = C.0

--------------------------Variables in the Equation-----------------

Variable	B	SE B	BETA	T	SIG T
With Two MIST DUMS					
LNDBH	.63699	.03715	.71025	17.145	.0000
BBAL	-.06582	6.60301E-03	-.32147	-9.968	.0000
MISTDUM1	-8.778878-03	.09071	-2.735E-03	-.097	.9229
CR	.11066	.02697	.12490	4.103	.0000
MISTDUM2	-.23705	.15892	-.04585	-1.492	.1362
BALLND	4.361720E-03	7.10191E-04	.25629	6.142	.0000
(CONSTANT)	1.24451	.23742		5.242	.0000

Table 2.--Analysis of the effect of dwarf mistletoe on lodgepole pine growth predictions.

Multiple R	.76223	Analysis of variance			
R Square	.58099		DF	Sum of squares	Mean square
Adjusted R Square	.58029	Regression	5	1228.04883	245.60977
Standard Error	.54343	Residual	2999	885.65745	.29532

F = 831.68012 SIGNIF F = 0.0

--------------------------Variables in the Equation--------------------

Variable	B	SE B	BETA	T	SIG T
LNDBH	.96846	.02257	.77789	42.907	.0000
CR	-.16997	.01288	-.15759	13.191	.0000
MISTDUM1	.01792	.05225	4.0821E-03	.343	.7316
BAL	-.01581	8.89660E-04	.25605	17.770	.0000
BALLND	5.871697E-03	5.43693E-04	.22022	10.800	.0000
(CONSTANT)	.30100	.11114		2.708	.0068

Height--Dwarf mistletoe had no discernible effect on height growth in either Douglas-fir or lodgepole pine.

Spread and Intensification

Between tree--In the Douglas-fir plots, number of infected trees increased from 42 in 1970 to 115 in 1983 (table 3).

Table 3.--Dwarf mistletoe-infected Douglas-fir by thinning levels by year.

Thinning level	Total No. trees in study	1970 No. trees	1970 % of total	1973 No. trees	1973 % of total	1978 No. trees	1978 % of total	1983 No. trees	1983 % of total
Check	271	25	9.2	29	10.7	38	14.0	46	17.0
8 X 8	584	9	1.5	24	4.1	38	6.5	49	8.4
14 X 14	266	7	2.6	11	4.1	18	6.8	20	7.5
20 X 20	122	1	0.8	0	0	0	0	0	0
All	1,243	42	3.4	64	5.1	94	7.6	115	9.2

In the lodgepole pine plots, number of infected trees increased from 88 in 1971 to 370 in 1984 (table 4).

Table 4.--Dwarf mistletoe-infected lodgepole pine by thinning levels by year.

Thinning level	Total No. trees in study	1971 No. trees	1971 % of total	1974 No. trees	1974 % of total	1979 No. trees	1979 % of total	1984 No. trees	1984 % of total
Check	1,020	24	2.4	33	3.2	45	4.4	80	7.8
8 X 8	2,486	22	0.9	30	1.2	87	3.5	138	5.6
14 X 14	1,072	14	1.3	21	2.0	27	2.5	94	9.0
20 X 20	429	28	6.5	36	8.4	41	9.6	58	13.5
All	5,007	88	1.8	120	2.4	200	4.0	370	7.4

Within tree--In the Douglas-fir plots, 42 trees were infected in 1970. The DMR increased on 14 trees, remained the same on 18 trees, and decreased on 10 trees (table 5).

Table 5.--Within tree intensification of dwarf mistletoe in Douglas-fir.

Thinning level	DMR increase or decrease +2	+1	0	-1	-2
	- - - -	No.	Trees	- - - -	
Check	4	8	12	1	0
8 X 8	0	0	4	4	1
14 X 14	1	1	2	1	2
20 X 20	0	0	0	1	0
Total	5	9	18	7	3

In the lodgepole pine plots, 88 trees were infected in 1971. The DMR increased on 21 trees, remained the same on 33 trees, and decreased on 34 trees (table 6).

Table 6. Within tree intensification of dwarf mistletoe in lodgepole pine.

Thinning level	DMR increase or decrease +3	+2	+1	0	-1	-2	-3	-4
	- - - -	- - - -	No.	Trees	- - - -	- - - -		
Check	1	1	2	12	7	1	0	0
8 X 8	0	1	3	7	10	0	0	1
14 X 14	0	0	6	7	1	0	0	0
20 X 20	0	2	5	7	12	2	0	0
Total	1	4	16	33	30	3	0	1

Mortality

In the Douglas-fir plots, 28 trees died in 13 years. In the lodgepole pine plots, 114 trees died in 13 years.

DISCUSSION

Growth Impact

Significant impacts of dwarf mistletoe on growth of Douglas-fir and lodgepole pine were not discernible. Several factors, either singly or in combination, could be involved.

Both the Douglas-fir and lodgepole pine stands were only lightly affected. The average stand DMR was less than 1 for both species when the study was initiated. During the first three plot measurements, many new infections were pruned, or trees were cut, unless infections occurred in the dwarf mistletoe check plots. Some trees were pruned each time the plots were measured. In 1983 and 1984, no pruning was done, and by the next scheduled remeasurements (1988 and 1989), a better indication of infection levels and their impact may be available. Reducing dwarf mistletoe impact by pruning was not an objective of the study, but pruning likely reduced both infection levels and impact.

Stocking density may be more important in determining growth than light infection of dwarf mistletoe, at least during early stages of stand development.

Stand age was also apparently important. All the trees except those on one Douglas-fir plot are less than 30 years old. Stands less than 30 years old do not normally show much of an effect from dwarf mistletoe infestations, but older stands respond in a measurable way to different infestation levels.

There was no effect of dwarf mistletoe on lodgepole pine growth, probably becasue there were too few trees with dwarf mistletoe ratings of 3 and greater to test effects of high ratings. Also, there may be more of a host response to systemic infection (Douglas-fir) than to local infection (lodgepole pine) (Hawksworth and Wiens 1972).

Live crown ratio (LCR) is correlated with tree growth. A tree with a 90 percent LCR would normally be growing much faster than one with a 20 percent LCR. There may also be a dwarf mistletoe connection here; it is reasonable to expect that a DMR of 3 would have much more of an impact on a tree with a 20 percent LCR than one with a 90 percent LCR. It would probably take severe infection levels (very high DMR's) to overcome a tree with such a large crown.

There was no effect of thinning on dwarf mistletoe. This is likely due to the young stand age and low dwarf mistletoe intensity. Thinning effects will be examined following future exams.

Spread and Intensification

Between tree--Given the low number of infected trees at the beginning of the study, the spread to uninfected trees was about what would have been expected.[3] Overall, the increase in infected Douglas-fir was from 3.4 to 9.2 percent of the total number of Douglas-fir in the study, not quite threefold. The increase in infected lodgepole pine was greater, 1.8 to 7.4 percent, or about fourfold.

For the study as a whole, the small number of infected trees both at the start and after 13 years helps explain the lack of growth impact, but on a tree-by-tree analysis, this is not so. A 9 percent infection level can be equated to an average stand DMR of much less than 1 (Hawksworth 1977, 1978b).

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[3] Personal communication from F. G. Hawksworth.

Within tree--In the Douglas-fir plots, slightly more trees (14) showed an increase in DMR than a decrease (10), but more (18) remained the same. In the lodgepole pine plots, however, fewer trees showed an increase (21) than those that showed a decrease (34). A like number (33) showed no change.

With trees as young as the ones in the study, this tendency for DMR to remain the same or decrease is not uncommon. The trees are growing rapidly, and they are either keeping up with or actually outgrowing the dwarf mistletoe. For example, a tree with a DMR of 2 may have light infection in both the lower and middle thirds. If this tree puts on enough height growth between plot readings to increase crown length enough that all infection is confined to the lower third, the tree then by definition has a DMR of 1. This can also happen with a heavy infection in the lower third and a light infection in the middle third (a DMR of 3). If the tree grows enough to where all the infection is confined to the lower third, then the DMR is decreased from a 3 to a 2. Decreases of two or more DMR classes occur, but most are probably caused by differences in the way the trees were rated by different persons in subsequent plot readings.

These slow rates of spread and intensification of dwarf mistletoe in both Douglas-fir and lodgepole pine are similar to those in red and white firs in California (Scharpf and Parmeter 1976).

Mortality

None of the mortality in either species could be attributed to dwarf mistletoe.

Some of the mortality in the Douglas-fir plots was caused by root disease (*Armillaria ostoyae*) (Romagn.) Herink, but more trees were missing than dead. Most of the missing trees were removed when a road was rebuilt through two of the plots; the remainder were apparently cut for Christmas trees.

Most of the mortality in the lodgepole pine plots was caused by breakage, either from heavy snow or by the breakup of the old dead overstory trees that were girdled in 1971.

RECOMMENDATIONS

Based on the study so far, we make these recommendations:

1. Continue the study. Some trends are developing in growth impact, spread, and intensification, but additional time is needed to elucidate overall effects.

2. Do no more pruning. This modifies the original study, but it will better define spread and intensification.

3. Continue the Douglas-fir measurement interval at 5 years (next reading in 1988). Growth impact should become more significant in another 5 years.

4. Change the lodgepole pine measurement interval to 10 years (next reading in 1994). No impact is yet evident, but probably will become so in another 10 years.

5. Continue with current management recommendations. DMR levels of 2 or less appear to be below the economic threshold. For precommercial stands recommendations include:

--Remove infested overstory trees by felling or girdling.

--When precommercially thinning infested stands, leave only crop trees that are uninfected or free of infections in the upper two-thirds of the crown (DMR of 2 or less).

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